INSTRUCTIONS FOR

PRECISION SENSITIVE INVERTER

MODEL 700

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BALLANTINE LABORATORIES, Inc.
BOONTON, NEW JERSEY

MODEL 700

PRECISION SENSITIVE INVERTER

INSTRUCTION BOOK

BALLANTINE LABORATORIES, INC.

Boonton, New Jersey

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BALLANTINE SENSITIVE INVERTER

MODEL 700

1. SPECIFICATIONS

Input Voltage Range ..... 10 uv - 100v

Threshold of Detection 1uv

Power Sensitivity ..... 10^{-19} watt

Ratio of DC Input to AC RMS Output ..... 1:100 & 10:1

Inversion Stability (above 100 uv input) 1%

Calibrator Accuracy 0.25%

Response Time (90% of final amplitude) ..... 0.25 sec

Input Conditions

DC Input Resistance for 1:100 ratio ..... 10 meg
for 10:1 ratio ..... 50 meg
AC Input Impedance 200k

Equivalent Input Noise Level) for 1:100 ..... Approx 3uv
Including Zero Offset) for 10:1 ..... Approx 3mv

Output Conditions

AC Output Frequency .....Line Frequency (approx 60 cps)

Max AC Output Level ..... 10v RMS

Total Distortion in Output Wave Form 2%

Min Load Impedance Permissible ..... 50,000 ohms

Output Impedance ..... Equivalent to 0.1uf

Power Requirements ..... 105-125v; 50-70 cps; 15 watts

Stability

Effect of line voltage change between 105 and 125 v 0.5%
Effect of line frequency change between 55 and 65 cps 2%
(Calibrator may be used to eliminate these errors if the change is a long-term effect)

Ambient Temperature Range ..... 0° to +35 C

Tubes ..... One 12AY7; one 12AT7; one 6X4; one 0A2; one 5651

Dimensions ..... 6" high; 6-3/4" wide; 10-7/8" long

Weight ..... 11 pounds

8/25/53

2. GENERAL SCOPE OF INSTRUMENT

The Ballantine Sensitive Inverter Model 700 fulfills the need for a stable, precise device which will permit the detection and measurement of dc potentials approaching microvolt levels without imposing heavy resistance loading on the source. The instrument inverts the dc potential under consideration to a 60 cps ac wave which is then amplified by a known factor to a level observable by one of a wide variety of ac voltmeters. This 60 cps wave appearing at the output of the Inverter has its amplitude and phase determined by the voltage and polarity, respectively, of the dc signal at the input.

When used ahead of a suitable ac voltmeter, the Model 700 makes possible

(a) the accurate measurement of dc potentials from 100 volts down to as low as 10 microvolts, and

(b) the detection of ac potentials as low as 1 microvolt.

The input resistance of the inverter is 50 megohms, or approximately 10 megohms depending on the range employed.

Very low frequency potentials from dc to 0.5 cps may also be observed and measured with the inverter since such an input signal will result in an amplitude-modulated wave having a carrier frequency of 60 cps and a peak amplitude proportional to that of the input signal.

The Model 700 Inverter may be combined with a vacuum tube voltmeter, multimeter, voltage amplifier, servo-amplifier, audio null detector-amplifier, oscilloscope, or any other device (responding 60 cps voltages in the range 100 microvolts to 10 volts RMS and having an input impedance greater than 50,000 ohms) in order to render that device sensitive to dc potentials ranging from 1 microvolt to 100 volts. Ballantine Sensitive Electronic Voltmeters are particularly suited for use with the Model 700 Inverter because of their high sensitivity, accuracy, and stability, and also because of the logarithmic voltage scale featured on all Ballantine voltmeters to preserve constant accuracy at all scale points. The logarithmic voltage scale is advantageous when the voltmeter sensitivity as the null point is approached. Although the Model 300 Electronic Voltmeter may be regarded as a standard instrument for use with the Inverter, inquiries are invited as to the preferred suitability of other types of combining Ballantine Voltmeters for performing dc or sub-audio voltage measurements under unusual conditions.

Measurements above 100 volts to a limit of 14 kilovolts dc may be made when a plug-in multiplier, Ballantine Model 1700, is used in conjunction with the inverter.

An important feature of the Model 700 Inverter is a built-in calibrator which permits correction of the major errors caused by a companion instrument or by the departure of line frequency and voltage from nominal values. Other features are

(1) high power sensitivity,
(2) high input resistance,
(3) distortion-free 60 cps sine wave output,
(4) immunity to 60 cps pick-up voltages,
(5) means for polarity sensing,
(6) extremely small zero drift.

3. OPERATION

The Model 700 is supplied with tubes and is ready to operate as received. Connect the power cord to a source of 105-125 volts, 50-70 cps, and turn on the ON-OFF switch. The red pilot light should glow when the power is on. Allow a five minute warm-up period before use. The inverter should be located on a horizontal surface, using the rubber feet provided at all times.

3.1 CONNECTION TO A COMPANION INSTRUMENT

A shielded output connector lead is provided for connection of the inverter to the input terminals of the companion instrument. If the connector lead is not satisfactory because of its length or terminal fittings, any other shielded connector of any practical length and having not more than .01uf loading capacitance may be used. The inverter output terminals are provided by a Type N coaxial receptacle.

3.2 DC VOLTAGE MEASUREMENTS

3.2.1. Desired Characteristics of Associated AC Voltmeter

In order to measure dc potentials accurately in the full specified range of the inverter the AC voltmeter connected to the output terminals should satisfy the following requirements: -

(a) Be capable of indicating over a range of 1 millivolt to 10 volts.
An instrument having a lower sensitivity than 1 millivolt can be employed but then the minimum measurable dc voltage will be restricted accordingly.

(b) Its indications should be of RMS voltage if a simple decimal correlation is to exist between the voltmeter reading and the observed dc voltage. Peak or average responding voltmeters are entirely acceptable in this respect if calibrated in terms of RMS voltage of sine wave.

(c) Its input impedance may not be less than 50,000 ohms at 60 cps.

3.2.2. Method of Measurement

Before proceeding with the following instructions it is recommended that for a full appraisal of the scope of the Inverter Section 3.3 on the use of the built-in calibrator, and Section 3.4 on polarity checking, should be read.

(a) Connect the output of the inverter to the input of an ac voltmeter meeting the above requirements. Use the special shielded connecting lead supplied, if possible.

(b) Before making connection to the voltage source, check the calibration accuracy of the inverter-voltmeter combination and calibrate if necessary. See instructions on the use of built-in calibrator, Section 3.3. The inherent stability of the inverter renders frequent repetition of this operation unnecessary if a high-quality companion voltmeter is used. (See section 3.2.1.)

(c) Connect the DC INPUT terminals of the inverter to the voltage source with the terminals marked L connected to that terminal of the source which is at, or nearer ground potential.

(d) Do not permit any external connection to exist between the inverter input terminal marked L and either the inverter case or inverter output terminals.

(e) To measure voltages: -

below 100 millivolts ...press the 1:100 VOLTAGE RATIO button,

above 100 millivolts ...press the 10:1 VOLTAGE RATIO button.

The magnitude of the DC input voltage is equal to the: -

RMS voltage reading ÷ 100 for ...1:100 VOLTAGE RATIO, and
RMS voltage reading x 10 for ...10:1 VOLTAGE RATIO.

A slight unsteadiness in voltage indication dependent on the meter damping of the AC voltmeter will occur for input voltages in the region of 10 microvolts on the 1:100 Ratio or for 10 millivolts on the 10:1 Ratio.

(f) For maximum accuracy, voltages below 100 microvolts should be measured as outlined in the following section.

3.2.3. Special Instructions for Accurate Measurements Below 100 Microvolts

(a) Short circuit the inverter input terminals and press the left-hand POLARITY button. Observe the voltage reading, which should be roughly 10 or more microvolts as read according to instructions of Section 3.2.2.(e).

(b) Disconnect the short circuit from the input terminals and connect the source voltage making certain that the positive polarity is connected to terminal H. Press the same POLARITY button and observe the voltage reading.

(c) The measured voltage is equal to the difference between these two readings.

3.2.4. Precautionary Measures When Making Low Level Measurements

It is sound practice (irrespective of the type of measuring device employed) when making a low level voltage measurement, AC or DC to observe certain precautionary measures in order to obtain accurate results. In the case of the Model 700 the effects of the following disturbances should be ascertained before making measurements of dc potentials below 10 millivolts.

(a) AC Fields at Line Frequency Surrounding the Inverter

Avoid operating the inverter in close proximity to such ac power equipment as voltage regulators, transformers, electric motors, etc., whose intense magnetic fields can possibly cause spurious indications.

(b) Voltages at Line Frequency Induced in Test Leads

A fortuitous 60 cps voltage impressed across the input terminals may produce an additional error depending on its amplitude relative to that of the dc potential being detected. To keep this error below 1% the 60 cps voltage should not exceed twice the dc potential.

Excessive 60 cps pick-up voltages can be avoided by the use of a twisted pair or a shielded cable if microphonics in the latter are not excessive. (See paragraph (f) below).

(c) Thermo-electric Potentials at the Junctions of the Test Leads and the Circuit Under Test

Such potentials occur at the junctions of dissimilar metals which, if included in the input circuit of the inverter, will probably cause errors when measuring low dc potentials.

Thermoelectric potentials may be avoided by either using the same metals on both sides of a junction, or maintaining the same temperature at all junctions. If soldered connections are employed a special low EMF solder should be used. The composition of a suitable solder for use with copper wire is 70% cadmium and 30% tin. This solder yields 1/5 of the thermal EMF or ordinary solder.

(d) Electrolytic Potentials as at (c) above

For critical measurements at microvolt levels over extended periods each test lead should be soldered to the voltage source by the special low EMF solder even though conditions (a) and/or (b) can be obtained in order to avoid the effects of electrolytic EMFs in the presence of moisture. Electrolytic potentials can be particularly troublesome when generated between terminals staked into insulating materials which are not immune to moisture absorption.

(e) R.F. Fields

Although the inverter is shielded and is provided with filters to reduce the effects of intense local RF fields, the presence of large RF currents at the various conductor junctions in the input circuit loop may introduce spurious dc arising from vestiges of a rectifier action at those junctions.

(f) Microphonics In Shielded Cable Employed at the Input

Most shielded cables produce microphonic voltages when they are subjected to movement or vibration. The effect of these microphonics is greater when working from a high source impedance than from a low source impedance and they may result in unsteadiness of the readings obtained with the inverter.

A shielded cable may be checked for excessive microphonics by subjecting the cable to normal movement while observing the dc voltage indication. Such action should not result in observable disturbances.

A twisted pair of test leads is preferable to a conventional shielded cable if there is no danger of excessive 60 cps pick-up voltages, or if commercially available, low-noise cable is not at hand.

3.2.5. Effects of Overload on 1:100 Range

Input levels up to 10 volts may be applied without risk on the more sensitive range owing to the protective influence of the RC input filter. However, unavoidable dielectric absorption of the capacitors may induce errors in measuring very low potentials immediately following overload depending upon the extent and duration of the latter and the internal resistance of the system being measured. If present, the condition may be recognized by the occurrence of a continuous drift in reading toward a stable value. Restabilization may be accelerated by short-circuiting the input terminals or by leaving the inverter set on the 10:1 range although the former method is more effective.

3.2.6. Accuracy in Various Ranges

Any errors introduced by the inverter on the 1:100 range will not exceed either 1% between 200 microvolts and 100 millivolts or 2% between 100 and 200 microvolts. For the 10:1 range the error will not exceed 2% from 100 millivolts to 100 volts.

At levels below 100 microvolts the errors will increase gradually as the input level decreases owing to unavoidable zero offset potentials and random noise. The error may be kept below 10% using the method described in section 3.2.4.

3.3 USE OF BUILT-IN CALIBRATOR

(a) Before calibrating the overall inverter-voltmeter combination make certain that there is no external connection between the inverter case or ground output terminal and the input terminal marked "L". Similarly "L" may not be connected to any part of the ground system of the companion instrument.

(b) Short circuit the input terminals. Depress the button for the ratio to be calibrated, and the .1 V CAL STD button located between the two range buttons. Adjust the CAL ADJ screw below the depressed ratio button to obtain a reading of precisely 10 volt on the companion voltmeter when calibrating the 1:100 ratio, and of precisely 10 millivolts when calibrating the 10:1 ratio.

3.4 USE OF POLARITY CHECKING DEVICE

Before proceeding as described below make certain that condition 3.3(a) above is met.

(a) Above 10 Microvolts

While the voltage whose polarity is required is impressed across the input terminals, press the POLARITY button in the range enclosing the input voltage level and note whether an up-scale or a down-scale deflection occurs.

An up-scale deflection indicates that the input terminal marked H is positive with respect to the input terminal marked L. Conversely, a down-scale deflection indicates that H is negative with respect to L.

A simple method of checking polarity is to press the POLARITY buttons one at a time in sequence from left to right and to stop on the button which causes the first observable deflection of the voltmeter pointer. Do not start from right to left.

(b) Below 10 Microvolts

Note the average of voltage reading, which will be rather unsteady at these low levels and then press the left-hand POLARITY button and note the new voltage reading. A change of approximately 10 microvolts indicates the input terminal H is positive with respect to L, whereas a change distinctly less than 10 microvolts indicates opposite polarity conditions.

3.5 DC VOLTAGE MEASUREMENTS ABOVE 100 VOLTS

Measurements of dc potentials from 100 to 14,000 volts may be made when the Ballantine Model 1700 Multiplier (obtainable from Ballantine Laboratories, Inc.) is attached to the input terminals of the Inverter, and so is inserted between the latter and the source. The loading resistance presented to the source of the multiplier is 40 megohms.

(a) Plug the multiplier into the Inverter binding posts while observing that the plug marked GND mates with the binding post marked L.

(b) Depress the 10:1 VOLTAGE RATIO button and connect the source of high voltage to be measured to the terminals of the Multiplier. The magnitude of the dc voltage applied to the Multiplier is equal to the: = RMS voltage reading of the companion ac voltmeter X 10,000.

3.5.1. Accuracy of Inverter-Multiplier Combination

The overall error for the range of 100 to 14,000 volts will not exceed 5%, provided the built-in calibrator is used as described in section 3.4.

4. CIRCUIT DESCRIPTION

A block diagram of the Model 700 Inverter is shown in Fig. 1 while the full circuit schematic is included at the end of this handbook.

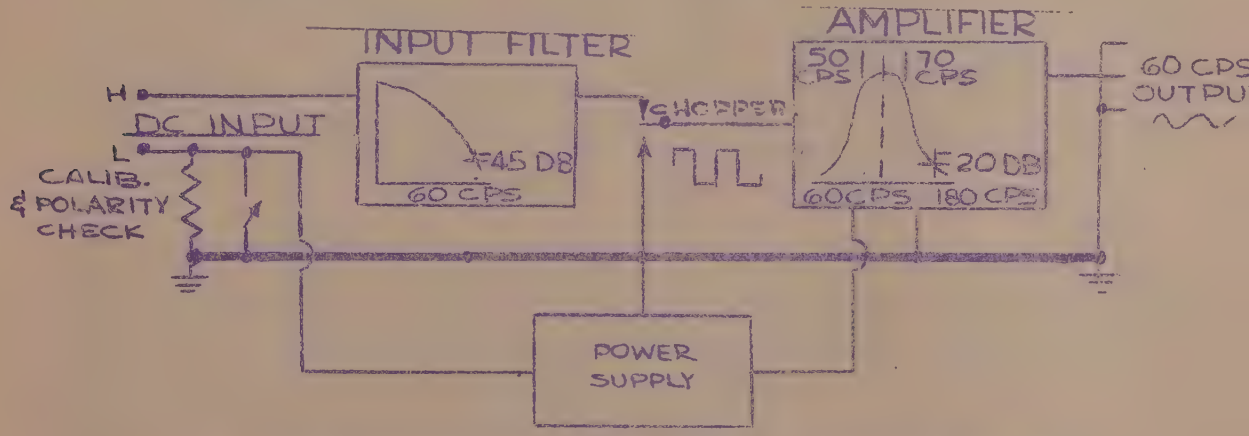


Fig. 1 - Block diagram of Ballantine Model 700 Sensitive Inverter

The circuit consists of a DC chopper, synchronized at line frequency, preceded by a low pass filter, and followed by a selective amplifier tuned to the band pass 50 to 70 cps.

Input Filter

The input filter serves to reduce errors caused by AC voltages appearing at the input. These AC voltages may exist in the DC voltage source or may be induced in the input leads by stray external fields. Attenuation of 60 cps input voltages is at least 45 DB, more than sufficient to eliminate errors caused by 60 cps pick-up in most laboratories and shops.

Amplifier

A stable, shock-mounted, amplifier serves to amplify the fundamental component of the chopper square-wave output. The fundamental frequency of the square-wave output will vary with line frequency since the chopper is synchronized with the line voltage. The amplifier has a flat pass-band of 50 to 70 cycles to allow for possible variations in line frequency. The gain of the amplifier drops sharply at frequencies below 50 cps and above 70 cps, and thus low frequency noise components, microphonics, and harmonics in the square-wave are severely attenuated relative to the fundamental. As a result the amplifier delivers a sinusoidal wave with less than 2% distortion.

Auxiliary Circuits

Auxiliary circuits include one for calibrating, and one for indicating the polarity of, the input voltage.

Calibrating

The calibrating circuit injects at the inverter input a stabilized DC potential of 0.1 volt which is calibrated to better than 0.1% accuracy and which has a long-term stability of the order 0.25%. The amplifier gain is adjustable so that when a voltmeter or an oscilloscope is employed to measure the inverter output, a scale reading of 10 volts or 10 millivolts may be obtained depending on whether the voltage ratio 1:100 or 10:1 respectively is being calibrated. This adjustable gain featured with the standard 0.1 volt reference source makes possible the elimination of the major errors in the AC measuring device following the inverter.

Polarity Determination

The circuit providing polarity indication is inserted by one of three buttons on the front panel. It adds in series with the input voltage a DC potential which causes an increase in AC output when the "High" terminal is positive with respect to the "Low" terminal, and vice versa.

5. SERVICE AND MAINTENANCE

5.1 GENERAL NOTICE

The construction and circuitry of this instrument does not admit of intensive servicing except by a technical group familiar with its intricacies,

and equipped with the specialized test equipment necessary for the purpose. It is therefore stressed that any major servicing problem be reported to Ballantine Laboratories, Inc. whose repair department will give it their prompt attention and will proffer advice and information to deal with the difficulty. Give full details concerning conditions of usage, model and serial number of instrument. If, after acting upon recommendations given below. In the case of an instrument for which the warranty period has lapsed, a reasonable charge will be made for repairs and for the replacement of faulty components in addition to defective tubes.

5.2 MAINTENANCE

(a) In view of the above statement, servicing of the Model 700 Sensitive Inverter should be limited to the replacement of the fuse, pilot light, and the 12AT7, 12AY7 and 6X4 tubes.

(b) The 5651 or the OA2 should not be replaced unless a precision potentiometer capable of measuring 100 millivolt with better than 0.1% accuracy is available for recalibrating the source of standard voltage.

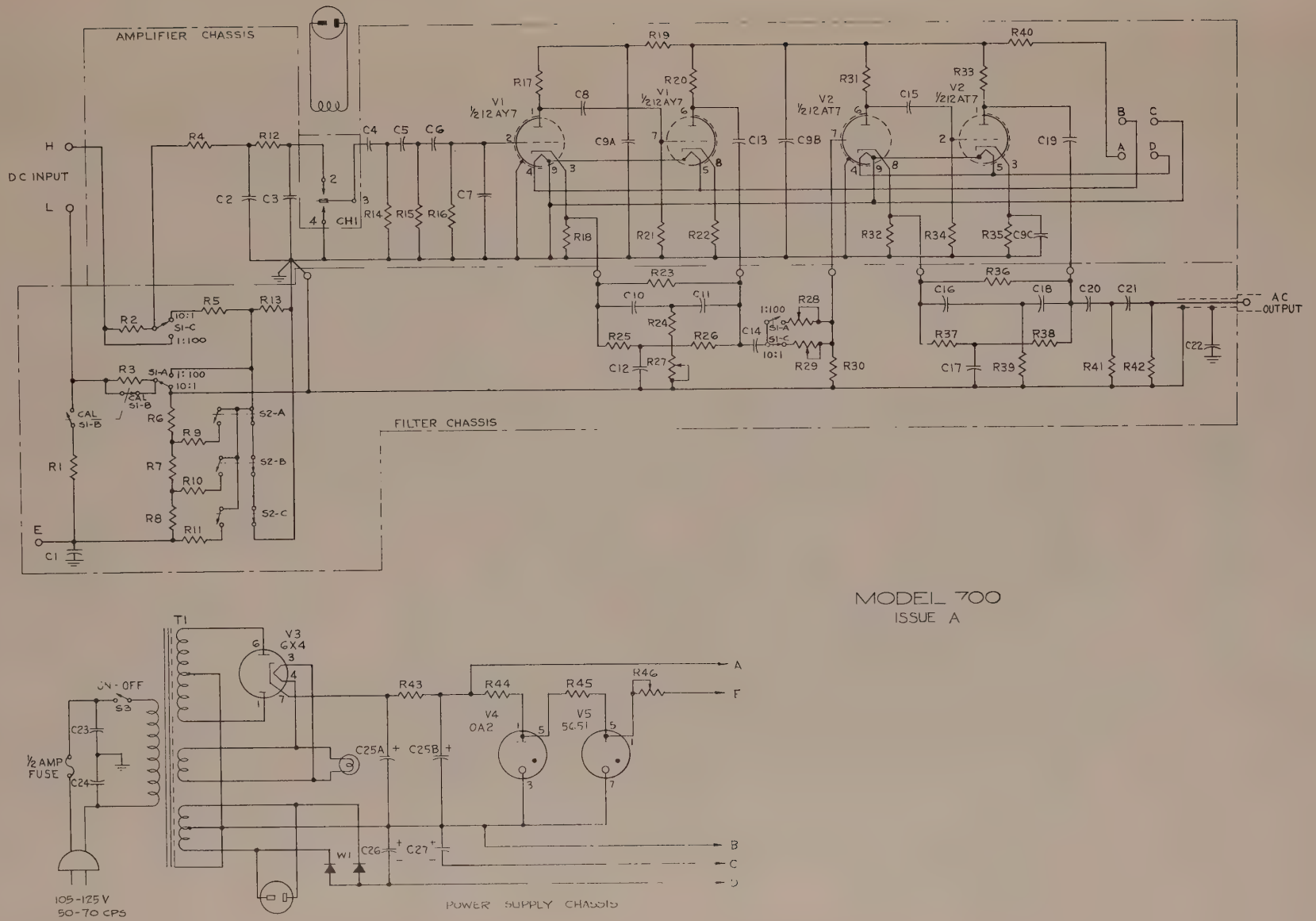
(c) To reestablish the standard 100 millivolt reference voltage after either one or both of these tubes have been replaced, unscrew the four nickel plated screws on the front panel and remove the instrument from the box. The reference voltage appears between the chassis and the L input terminal when the .1 v CAL STD button is operated. Using the potentiometer to measure this voltage (L terminal positive) obtain the 100 millivolt calibration potential by resetting the screwdriver adjustment screw located on the right-hand side of the chassis near the ON-OFF switch.

6. WARRANTY

We warrant each instrument sold by us to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes or batteries, which shall within 1 year after shipment to the original purchaser prove upon our examination to be defective.

7. SHIPPING INSTRUCTIONS

If it should become necessary to return the instrument to us for servicing, make certain that at least 3 or 4 inches of padding material surround the instrument. Ship via Railway Express collect.



MODEL 700
ISSUE A

REFERENCE LIST OF PARTS *

Part No.	CONDENSERS			
C1 -	0.0015 mfd.,	500 Volt,	20%,	Erie Type 362-152
C2 -	0.22 mfd.,	100 Volt,	20%,	Sprague Type 88P22401S2
C3 -	0.22 mfd.,	100 Volt,	20%,	Sprague Type 88P22401S2
C4 -	0.005 mfd.,	200 Volt,	20%,	Cornell-Dubilier Type ZNW2D5
C5 -	0.005 mfd.,	200 Volt,	20%,	Cornell-Dubilier Type ZNW2D5
C6 -	0.005 mfd.,	200 Volt,	20%,	Cornell-Dubilier Type ZNW2D5
C7 -	0.0006 mfd.,	300 Volt,	20%,	Cornell-Dubilier Type 1W5G6
C8 -	0.005 mfd.,	200 Volt,	20%,	Cornell-Dubilier Type ZNW2D5
C9A -	20 mfd.,	300 Volt,		Cornell-Dubilier Type UP2230C
C9B -	20 mfd.,	300 Volt,		Cornell-Dubilier Type UP2230C
C9C -	20 mfd.,	25 Volt,		Cornell-Dubilier Type UP2230C
C10 -	0.047 mfd.,	100 Volt,	5%,	Sprague Type 88P47351S2
C11 -	0.047 mfd.,	100 Volt,	5%,	Sprague Type 88P47351S2
C12 -	0.1 mfd.,	100 Volt,	5%,	Sprague Type 88P10451S2
C13 -	6 mfd.,	150 Volt,	20%,	Cornell-Dubilier Metapup Style H
C14 -	0.05 mfd.,	400 Volt,	20%,	Cornell-Dubilier Type ZNW4S5
C15 -	0.005 mfd.,	200 Volt,	20%,	Cornell-Dubilier Type ZNW2D5
C16 -	0.1 mfd.,	100 Volt,	5%,	Sprague Type 88P10451S2
C17 -	0.22 mfd.,	100 Volt,	5%,	Sprague Type 88P22451S2
C18 -	0.1 mfd.,	100 Volt,	5%,	Sprague Type 88P10451S2
C19 -	6 mfd.,	150 Volt,	20%,	Cornell-Dubilier Metapup Style H
C20 -	0.25 mfd.,	200 Volt,	20%,	Cornell-Dubilier Type MP2P25
C21 -	0.25 mfd.,	200 Volt,	20%,	Cornell-Dubilier Type MP2P25
C22 -	0.01 mfd.,	400 Volt,	20%,	Sprague Type 67P10304
C23 -	0.006 mfd.,	500 Volt,	20%,	Cornell-Dubilier Type 1D5D6
C24 -	0.006 mfd.,	500 Volt,	20%,	Cornell-Dubilier Type 1D5D6
C25A-	20-80 mfd.,	450-350 Volt,		Mallory Type FP235
C25B-	20-80 mfd.,	450-350 Volt,		Mallory Type FP235
C26 -	1,000 mfd.,	15 Volt,		Cornell-Dubilier Type UP1M-15
C27 -	3,000 mfd.,	10 Volt,		Cornell-Dubilier Type UP3M-10

T1 - Transformer, Ballantine Special

FUSE - Littelfuse Type 3AG, ½ ampere

PILOT LIGHT - #47, General Electric Supply

* See attached wiring diagram.

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REFERENCE LIST OF PARTS *

Part No.	RESISTORS		
R1 -	170,000 ohms,	1%,	Shallcross Type 12, Alloy E
R2 -	50,000,000 ohms,	1%,	Wilkor Type CP-2. Code 2A
R3 -	198 ohms,	1%,	Shallcross Type BX12E, Alloy E
R4 -	200,000 ohms,	5%,	Wilkor Type CP-½, Code 2A
R5 -	50,000 ohms,	1%,	Wilkor Type CP-½, Code 2A
R6 -	2,000 ohms,	5%,	Allen-Bradley Type EB
R7 -	39,000 ohms,	5%,	Allen-Bradley Type EB
R8 -	1.0 megohm ,	5%,	Allen-Bradley Type EB
R9 -	1.0 megohm ,	5%,	Allen-Bradley Type EB
R10 -	1.0 megohm ,	5%,	Allen-Bradley Type EB
R11 -	1.0 megohm ,	5%,	Allen-Bradley Type EB
R12 -	200,000 ohms,	5%,	Wilkor Type CP-½, Code 2A
R13 -	60 ohms,	1%,	Wilkor Type CP-½, Code 2A
R14 -	22,000,000 ohms,	10%,	Allen-Bradley Type EB
R15 -	22,000,000 ohms,	10%,	Allen-Bradley Type EB
R16 -	10,000,000 ohms,	10%,	Allen-Bradley Type EB
R17 -	1,000,000 ohms,	10%,	Shallcross Type 30
R18 -	20,000 ohms,	1%,	Nobeloy Type NF½
R19 -	120,000 ohms,	10%,	Allen-Bradley Type EB
R20 -	33,000 ohms,	5%,	Allen-Bradley Type EB
R21 -	2,000,000 ohms,	10%,	Allen-Bradley Type EB
R22 -	1,000 ohms,	5%,	Allen-Bradley Type EB
R23 -	250,000 ohms,	1%,	Wilkor Type CP-½
R24 -	12,000 ohms,	1%,	Wilkor Type CP-½
R25 -	56,000 ohms,	1%,	Wilkor Type CP-½, Code 2A
R26 -	56,000 ohms,	1%,	Wilkor Type CP-½, Code 2A
R27 -	20,000 ohms,	20%,	IRC Volume Control Type RQ11-119
R28 -	50,000 ohms,	20%,	IRC Volume Control Type PQ11-123
R29 -	50,000 ohms,	20%,	IRC Volume Control Type PQ11-123
R30 -	200,000 ohms,	1%,	Wilkor Type CP-½, Code 2A
R31 -	750,000 ohms,	10%,	Allen-Bradley Type EB
R32 -	7,500 ohms,	1%,	Wilkor Type CP-½, Code 2A
R33 -	33,000 ohms,	5%,	Allen-Bradley Type EB
R34 -	2,000,000 ohms,	10%,	Allen-Bradley Type EB
R35 -	750 ohms,	5%,	Allen-Bradley Type EB
R36 -	150,000 ohms,	1%,	Wilkor Type CP-½, Code 2A
R37 -	40,000 ohms,	1%,	Wilkor Type CP-½, Code 2A
R38 -	40,000 ohms,	1%,	Wilkor Type CP-½, Code 2A
R39 -	20,000 ohms,	1%,	Wilkor Type CP-½, Code 2A
R40 -	10,000 ohms,	10%,	Allen-Bradley Type EB
R41 -	51,000 ohms,	10%,	Allen-Bradley Type EB
R42 -	51,000 ohms,	10%,	Allen-Bradley Type EB
R43 -	2,400 ohms,	5%,	Allen-Bradley Type HB
R44 -	9,100 ohms,	10%,	Allen-Bradley Type HB
R45 -	20,000 ohms,	10%,	Allen-Bradley Type HB
R46 -	5,000 ohms,	10%,	Clarostat Type 43-5000

* See attached wiring diagram.

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